BACTERIAL COMMUNITIES FROM MARINE, SHALLOW HYDROTHERMAL VENTS OFF THE EOLIAN ISLANDS (ITALY)

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Abstract.

The marine shallow hydrothermal vents represents a more accessible field of study than the deep-sea oceanic sites. Bacterial communities living in the marine, shallow hydrothermal vents off the Eolian Islands have been studied in water and sediment samples. The microbial abundances in water samples from shallow vents, estimated by epifluorescence microscopy were in the order of 10^4- 10^6 cells·ml^{-1} similar to the lowest values observed at the Galapagos Rift. Microbial abundances in the sediment samples ranged from 10^6 to 10^8 cells·g^{-1}. The densities in phototrophic picoplankton, or picophytoplankton, ranged from 10^2 to 10^4 cells·ml^{-1} and were higher than temperate marine zones. Chemolithotrophic sulphur-oxidising bacteria varied in the order of 10^2 and 10^4 MPN·ml^{-1} and were more abundant in the sediment samples where they reached values of 10^7 MPN·g^{-1}.

Key-words: thermal vents, bacteria, Tyrrhenian sea

Introduction

Chemosynthetic production by marine bacteria is now known to support diverse thriving and unusual communities of living organisms in location such as deep-sea hydrothermal vents that were not to be expected a decade ago. With the discovery of deep-sea hydrothermal vents, numerous scientists attempt to isolate typical obligate chemolithotrophic sulphur bacteria. Aerobic chemosynthesis seems to be responsible for the bulk of productivity at deep-sea hydrothermal vents. In these sites, other than aerobic chemosynthesis anaerobic chemosynthesis, by sulphur- and sulphate-reducing as well as methanogenic bacteria, has also been reported. In addition, the presence of all types of bacterial metabolism has been demonstrated (1, 2).

The approach to shallow, marine hydrothermal vents is generally more complex because the presence of the sun-light represents the usual energy source for the phototrophic planktonic organisms. The marine shallow hydrothermal area off the Eolian Islands (Italy) represents a more accessible field of study regarding extreme environments than the deep-sea oceanic sites.

Since 1983, species belonging to the Archea dominion, both thermophilic, *Staphylothermus marinus* (3), *Archeoglobus fulgidus* (4), *Thermotoga* (Prieur, personal communication) and *ultrathermophilic Pyrodictium* (5) and *Pyrococcus furiosus* (6) have been isolated from the coastal area of Vulcano Island. Furthermore, a new species of *Thiobacillus, Th. prosperus*, has been recognised (7).

Materials and Methods

Bacterial communities living in the marine, shallow hydrothermal vents off the Eolian Islands have been studied in water and sediment samples collected from different sites by SCUBA-divers and temperatures were recorded immediately by a multiparameter probe during sample collection.

The microbial abundances from water and sediment samples were estimated by epifluorescence microscopy (8). The concentration of ATP (9) was used as an indirect measure of living microbial biomass in water samples. The densities in phototrophic picoplankton, or picophytoplankton were evaluated according to Gugliandolo and Acosta Pomar (10). The estimation of the chemolithotrophic sulphur-oxidising bacteria, able to grow on thiosulphate as the only energy source, was made in the S6A medium (11).

Thiosulphate-oxidizing strains were tested for morphological, cultural and biochemical characteristics. The viable counts in heterotrophic, mesophilic bacteria were evaluated onto Marine Agar 2216 (Difco) plates incubated at room temperature for 7 days. Heterotrophic isolates were tested for the biochemical characteristics of the API 20NE system. Heterotrophic, thermophilic bacterial numbers were evaluated in Marine Broth incubated at 60 and 75°C for 3-5 days.

Results and Discussion

A briefly description of the sampling sites is given in Table 1.

The microbial abundances in water samples from shallow vents, were in the order of 10^4- 10^6 cells·ml^{-1} similar to the lowest values observed at the Galapagos Rift (12, 13). The concentration of ATP was found to be two to four times higher than in the surface waters of the same region. Microbial abundances in the sediment samples ranged from 10^6 to 10^8 cells·g^{-1} (wet weight).

The densities in picophytoplankton, ranged from 10^2 to 10^4 cells·ml^{-1} and were higher than temperate marine zones. Yellow-orange autofluorescent prokaryotic organisms, ascribable to cyanobacteria, were more abundant than the red autofluorescent ones.

Table 1. Sampling sites at the Eolian Islands.

Station	Sample	Origin	Site	Temperature (T°C)	Depth (m)	pH
A	A1	Water	Vulcano - P.to Levante	25	0.3	5.3
	A2	Water	Vulcano - P.to Levante	25	0.3	5.2
	A3	Water	Vulcano - P.to Levante	25	0	5.2
S	S1	Sediment	Vulcano - P.to Levante	93	0	
	S2	Sediment	Vulcano - P.to Levante	75	0	
	S3	Sediment	Vulcano - P.to Levante	85	0	
B	B1	Water	Vulcano - P.to Levante	24	6	6.4
	B2	Water	Vulcano - P.to Levante	43	6	6.4
	B3	Water	Vulcano - P.to Levante	65	0.7	5.2
T	T1	Sediment	Vulcano - P.to Levante	24	6	
	T2	Sediment	Vulcano - P.to Levante	43	6	
	T3	Sediment	Vulcano - P.to Levante	65	0.7	
U1a	U1a	Water	Vulcano - P.to Levante	48	6.3	5.6
	U1aS	Sediment	Vulcano - P.to Levante	48	6.3	
U1b	U1b	Water	Vulcano - P.to Levante	44	5	6.76
U3	U3	Water	Vulcano - La Roya	49	3	6.03
	U3S	Sediment	Vulcano - La Roya	49	3	
U4	U4	Water	Vulcano - P.ta Conigliara	45	15	6.09
	U4S	Sediment	Vulcano - P.ta Conigliara	45	15	
U5	U5	Water	Lipari - Inzolfata	30	3.1	5.86
	U5S	Sediment	Lipari - Inzolfata	30	3.1	
U6	U6	Water	Panarea - Campo 7	54	18	5.36
U7	U7	Water	Panarea - La Calcara	95	19.8	5.1
	U7S	Sediment	Panarea - La Calcara	95	19.8	

The counts obtained for chemolithotrophic sulphur-oxidising bacteria varied in the order of 10^2 and 10^4 MPN·ml^{-1} and were more abundant in the sediment samples where they reached values of 10^7 MPN·g^{-1}. Numerical analysis based on 42 characteristics of the 25 sulphur-oxidising bacteria isolated from water and sediment samples off the Island of Vulcano produced three separate ecotypes of the:

i) obligate chemolithotrophs, assigned to a *Thiobacillus*-like organisms, present only in venting water samples;

ii) facultative chemolithotrophic bacteria, assigned to *Thiobacterium*-like bacteria, recorded in both water and sediment samples;

iii) heterotrophic sulphur oxidisers, assigned to *Pseudomonas*-like bacteria, present in sediment (11).

Filamentous forms that cover the substratum around the vents were recorded from the deepest hot sources (20 m depth) off the Island of Panarea. Microscopic examination of the whitish mat revealed *Thiothrix*-like bacteria containing sulphur inclusions as the dominant filamentous form in this microbial community (Fig. 1).

Viable counts in heterotrophic, mesophilic bacteria, ranged from 10^2 and 10^4 CFU·ml^{-1} from water and 10^3 to 10^5 CFU·g^{-1} from sediment samples. Almost all strains isolated were able to hydrolyse gelatine; the fermentative strains appeared to be very few, moreover the occurrence of nitrate to nitrite reducing bacteria does not exclude the possibility of a facultative anaerobic metabolism. Heterotrophic, thermophilic bacterial numbers were higher in the sediment than in the water samples. Strains of thermophilic bacterium *Thermus aquaticus*,